RATIONAL WASTE: THE POLITICAL-ECONOMY OF DESALINATION

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Abstract. This paper explores the economic and political dimensions of responding to water scarcity by increasing supply rather than reducing demand with examples from San Diego (US), Almería (ES) and Riyadh (SA). Each case explains how leaders benefit by obscuring the costs of desalinated supplies. In San Diego, marginal costs are diffused among customers. In Almería, they are absorbed by a government eager to reduce unsustainable groundwater use. Rulers in Saudi Arabia, meanwhile, absorb costs in exchange for political quiet. Each case discusses potential means of extending current policies (greater regional trust, improved groundwater condition, and reduced agricultural irrigation, respectively) as well as reforms to facilitate the adoption of policies with lower economic and social costs.

The mechanics of water scarcity

Water is an important input to many activities that directly and indirectly benefit humans, but increasing water scarcity (or water stress) means that there is not enough water to meet all demands (Zetland, 2014). Options for addressing scarcity must address the perceived excess of demand over supply.

Demand can be decreased by reducing someone's desire for water or reducing the water required to meet someone's (unchanged) desire. Reductions could happen, for example, by replacing a lawn with a rock garden or installing a drip irrigation system to grow the same plants with less water. Economists represent either change as a fall in demand, i.e., an inward shift in the demand curve. A third method reduces "quantity demanded" by increasing the price of water such that people reduce uses of marginal benefit, such as an extra five minutes in the shower.

Supply can be *increased* in symmetric ways. A change in tastes (e.g., accepting recycled wastewater) increases useful supplies. A technical innovation (e.g., cheaper desalination technology) delivers more water at the same cost. The third method

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Table 1. Scarcity can be reduced by shifting demand in, shifting supply out, or using price to slide down the demand curve or up the supply curve.

	Tastes (shift)	Technology (shift)	Incentives (slide)
Reduce demand	Reduce desires	Meet same desire with less	Give up marginal desires
Increase supply	Increase acceptance	Produce same quantity with less	Buy marginal sources

increases quantity supplied by spending more on conveyance, treatment technology, and so on. Table 1 summarizes these options fr allocating demand and supply.

Local preferences dictate the appropriate response to scarcity. A coastal community facing scarcity could reduce demand by raising prices or installing low-consumption appliances, but locals may prefer to augment supply via desalination. Social harmony and economic efficiency will be greater if the beneficiaries of local decisions bear their costs in equal proportions. Harmony and efficiency will fall if benefits and costs go to different groups, but this paper will argue that such mismatches are neither necessary nor sufficient to block inefficient policies if those policies contribute to the popularity of political leaders.[1]

The political economy of water scarcity

Conventional cost-benefit analysis collapses time, space and uncertainty into a net present value (NPV) that makes it possible to compare policies, but that simplification will be misleading is those characteristics reveal significant variations in temporal, spatial and informational impacts. An assumption — people prefer benefits to be known/local/current and costs that are unknown/distant/future — explains why politicians emphasize local and current benefits of a policy while downplaying, obscuring or delaying its costs. Those voter biases also explain why citizens support low net-present-value projects over (socially and economically) better alternatives that do not pander to their interests (Olson, 1971).

This flip-side of this logic explains how voters are more likely to make better choices from a fiscal, environmental and social perspective when they face the full

[1]We will assume that leaders, ceteris paribus, prefer a popular policy — regardless of their democratic legitimacy.

cost of their actions. We will use these reasonable assumptions to define a choice as "sustainable" when costs and benefits fall on the same group and "unsustainable" when deciders get benefits but outsiders experience a significant share of costs (i.e., negative externalities). Switching perspectives a little, we will also label policies as "pragmatic" when they are sustainable and "populist" when they are not. Those labels are based on common perception that pragmatic policies recognize relevant, perhaps unpopular, facts while populist policies tend to ignore future, distant costs. Taking those classifications as given, we can also assume that voters and citizens will resist efforts to "internalize the externalities" of a policy as they often see a move to impose costs on them as a straight loss rather than the fair price for continuing to receive benefits.

We will use these ideas to explore three case studies that vary in their populism and sustainability. Our purpose is not to expose or estimate the negative externalities in these cases. We will instead focus on the political-economic impacts of current policies, how increasing water stress is changing those impacts, and the potential options for politicians who want to preserve their popularity.

Building homes in San Diego

San Diego and neighboring municipalities share approximately one year of surface storage capacity and possess virtually no groundwater reserves (SDCWA, 2013). The region ("San Diego," for convenience) gets most of its water from a complex aqueduct system that extends hundreds of kilometers to the north and east. This system is owned and operated by the Metropolitan Water District of Southern California (Met).

Met is governed as a cooperative by 26 member agencies whose payments for water cover Met's infrastructure costs. The San Diego County Water Authority (Authority) is Met's largest member agency in terms of water purchases and payments. The Authority is, in turn, the largest provider of wholesale water to San Diego (i.e., the city and neighboring municipalities). The Authority and Met have a complex relationship that predates their origins.[2] Their most recent conflict — over

[2]Met was founded in Los Angeles, which has maintained a competitive dominance over San Diego for over 100 years; see Zetland (2008).

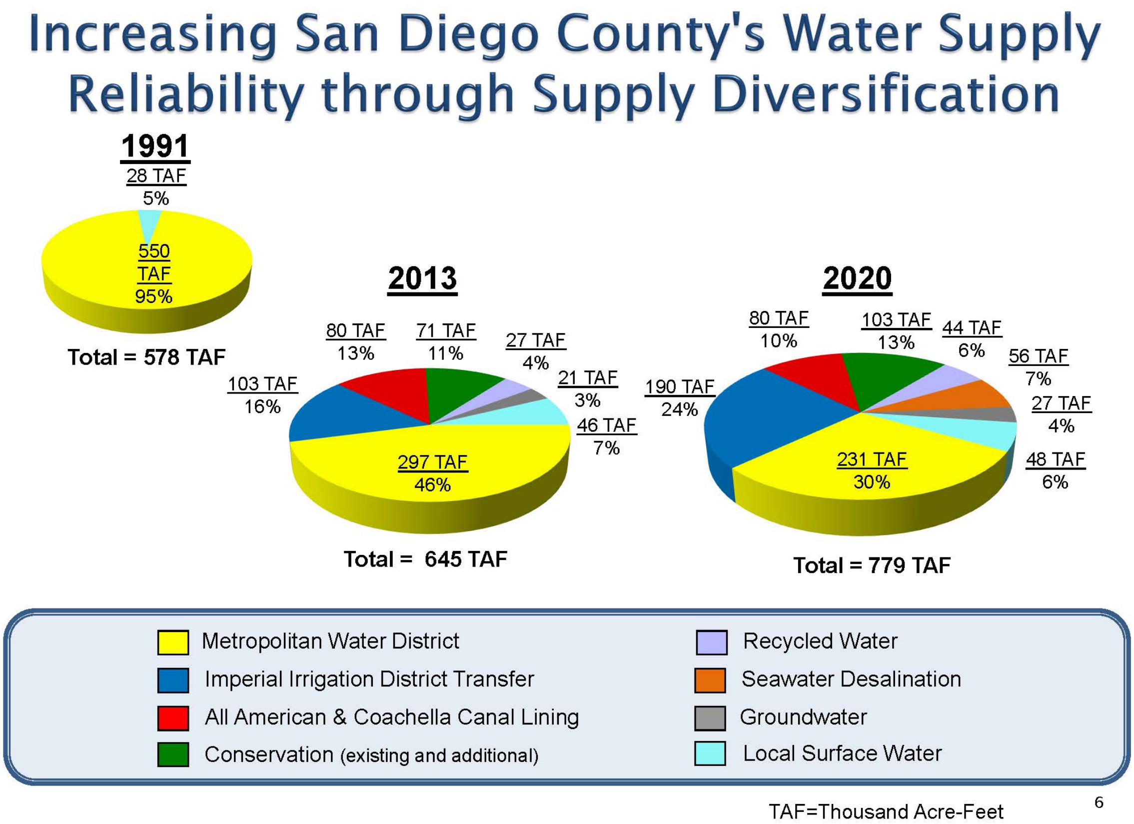

FIGURE 1. The evolution of San Diego's supplies. Source: http://bit.ly/SasYxn

the price of using Met pipes to "wheel" water the Authority bought from distant farmers — has been running for nearly 20 years and shows no sign of ending soon (Maven, 2014).

These basic facts mean that San Diegans pay two costs for their water supply. The first is the cash cost of water, energy and infrastructure. The second is the cost (or risk) of losing access to imported water. Although some of this risk is physical (losses due to canal leaks, pipe breaks, weather variation, and so on), the largest share comes from political risk. San Diego can only import its water through Met's network, and their poor relations create uncertainty and an impression of water scarcity. The Authority is trying to dispel that impression (City News Service, 2014). Figure 1 provides a reasonable impression of San Diego's current dependency and dream of future freedom (Zetland, 2008).

Figure 1 shows how San Diego plans to diversify its supply portfolio, but what about reducing demand? Local water consumption is approximately 150 gallons/capita/day (gcd, equal to 570 liters/capita/day), which is high by global standards but average

for the US (SDCWA, ated). This consumption results in intensive and extensive benefits (i.e., the benefits from using water in an arid region and growing the population, respectively) to politicians, land developers and migrants who want cheap housing. Zetland (2009) discusses the foundations of that alliance, which must be effective, if we are to believe those who claim San Diego decided to spend $900 million on a desalination plant because "the growth must go on."

A tolerance for demand. Water demand in San Diego fell from ±200 gcd a decade ago to current levels of ±150 gcd due to equipment upgrades and "scarcity awareness" (SDCWA, ated). The Authority has not used higher prices to reduce quantity demanded, but prices are still low enough to make it affordable for residents to spray 40 percent of their water on outdoor landscaping (SDCWA, ated).

Why aren't prices being raised? The first answer is simple. The utility is collecting enough revenue to cover costs from current prices and volumes. The second is populist. Higher prices would upset customers. The third is cynical. Politicians and property developers want to sell more houses to new arrivals. Higher prices would discourage them. The fourth is psychological. Higher prices may cause a discrete change in tastes that results in dead lawns and — more important — lower revenues to the utility. Fifth, higher prices that reduce demand do not increase San Diego's water security. Lower imports from Met decrease San Diego's claim to Met water that it may want to invoke in a drier, future year.

The local benefits of supply. Legal, logistical and environmental constraints make it unlikely that San Diego will get more water from Met, and political acrimony threatens existing flows, so San Diego needs to source its own supply from wastewater or seawater. San Diegans rejected wastewater recycling (a cheaper option) after a furious "toilet to tap" campaign led by the mayor.[3] They turned, instead, to a new desalination plant that is scheduled to begin producing 50 million gallons per day (190,000 m^3/day, or 56,000 acre-feet per year) by the end of 2015 (Zetland, 2012).

Desalination is more expensive than all other supply or demand options, but leaders like it for reducing the region's dependence on Met. So they set out to minimize

[3]Poseidon Inc, the company behind the desalination project, has denied involvement in that campaign, but it has contributed to the mayor's electorial campaigns (Flannery, 2008).

the financial impact of the billion dollar plant by hiding the plant's marginal cost in all customers' bills. We can calculate the magnitude of this obfuscation with some help from the Authority, which projects that "the average household's water bill would increase approximately \$5 to \$7 a month by 2016 to pay for" a 7 percent increase in supply (see SDCWA (2012) for the monthly charge and Figure 1 for the increase). These two numbers allow us to compare the current, average-cost plan (all customers pay \$6 per month) to a marginal-cost plan in which 7 percent of customers pay the marginal cost of water they demand as a result of moving to San Diego, i.e., an additional cost of $\frac{\$6*100\%}{7\%}$ =\$86 per month over the current service costs. The difference — nearly \$1,000 more per year — would surely frighten would-be migrants.[4]

Figure 2 illustrates how demand (solid) interacts with two different prices aimed at covering the costs of supply — the dashed line with S_b representing baseline supply and S_d representing the cost of additional, desalinated supplies. The first set (P_1, Q_1) shows how a price based on average cost results in a quantity demanded that necessitates the desalination plant. The second set (P_2, Q_2) shows how a price based on the marginal cost of additional water (from desalination) results in a quantity demanded that's low enough to make a desalinated supply redundant.

But this story is not just about quantities, but flexibility and risks. An increase in price that reduces consumption when supplies are available leaves less room for cutting demand when supplies are scarce. More intriguingly, a reduction in water purchases from Met lowers the Authority's "average draw" on Met water, a reference point for allocating scarce water among Met's member agencies that San Diego wants to preserve for future emergencies (a 20 percent cut from Q_1 is less painful than a 20 percent cut from Q_2). Desalination, in contrast, allows current behavior and growth to occur at a small cost to the average customer. You can see why leaders prefer it.

But what about the plant's climate change impact? The plant will emit 61,000 tons of CO_{2e} annually (Voutchkov, 2008). The estimated damages from those emissions varies, but let's assume a negative impact \$50 per ton (roughly \$3 million per

[4]The Authority's "all-in" price is currently about \$1,300 per acrefoot, but only \$1,006/af when overhead costs are excluded. That price is less than half the \$2,200/af cost of desalinated water (SDCWA, 2013, 2012).

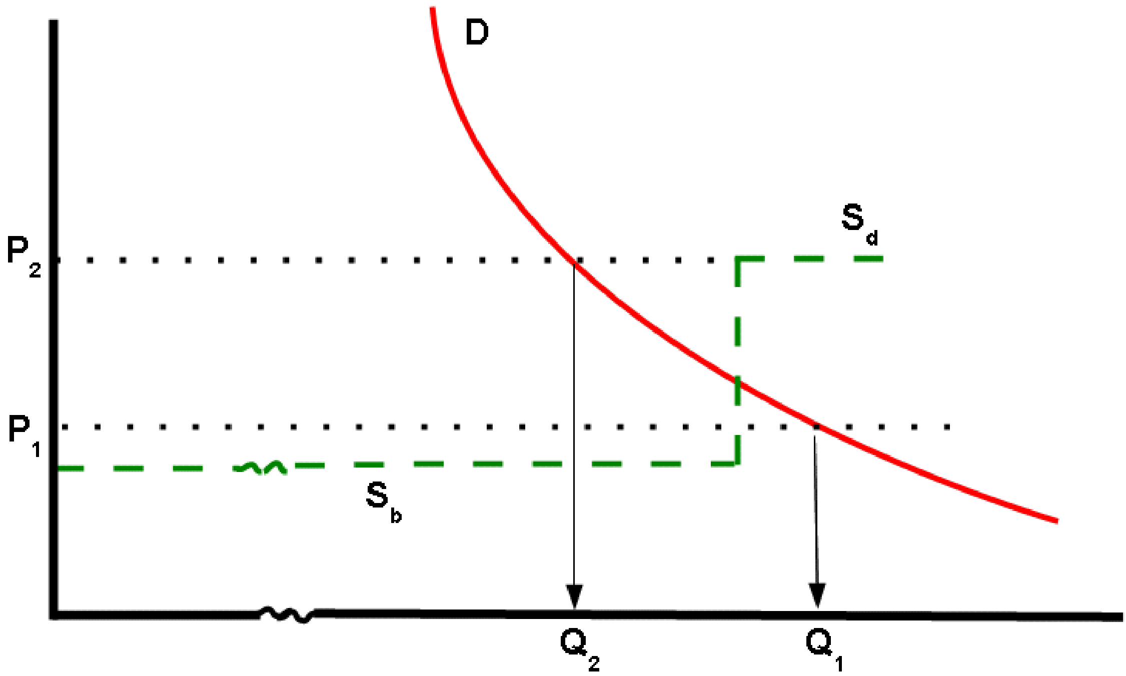

FIGURE 2. San Diego charges a low, average-cost price (P_1) on water, such that quantity demanded (Q_1) justifies the more expensive desalinated supply (S_d). Prices at P_2 (representing the marginal cost of desalinated water) would result in a lower quantity demanded (Q_2). Source: Author

year), which works out to less than one cent per human. Using a different method — the cost of offsetting emissions under California's cap and trade system — we could allow San Diego customers to internalize their externality at the current price of \$12/ton CO_{2e}, which is roughly \$750,000 per year or about \$0.25 per resident. These numbers — too low to register globally or locally — will disappoint activists.

The only relevant fact from these calculations arrives as an afterthought: Voutchkov (2008) assumes the plant will be carbon neutral because 47,000 tons of its emissions will be offset by a reduction in energy-intensive water imports from Met. Perhaps he would be surprised to read (RWMG, 2013), which states regional leaders' plan for a 30 percent increase in population by 2035.[5] Voters might think twice if they were told their \$1 billion was going to subsidize new arrivals, but leaders probably give their "reliable supplies" speech to a different group than hears the "growth and prosperity" speech.

[5]Or perhaps not. Voutchkov is a Senior Vice President at Poseidon LLC, and he omits population growth from his analysis.

The politics of stability. The benefits of growth and water use to the majority come with costs (money, environmental impacts) that bother a minority, but this example illustrates important ideas. The benefits of increasing supply rather than reducing demand as a means of reducing dependency on Met and spreading high costs over many customers and decades to hide the heavy, cumulative impacts of growth.

The desalination plant does not make sense from a financial and environmental perspective compared to raising prices because it costs $1 billion more, uses large quantities of energy, and does little to reduce San Diego's consumption of Met water, but it makes a lot of sense for managers who value local reliability and growth. It also clarifies how the real solution to water scarcity is neither a reduction in demand nor an increase in supply but more trust between Met and San Diego. Trust would make it easier for Met to allocate regional water and San Diego to grow without new supplies, but there is no trust. That's why developers and politicians want their own desalination plant.

Exporting food in Spain

It is conventional wisdom that the lowest value water uses are for irrigation and the highest cost water sources are from desalination, but the value of irrigation water in Spain can exceed the cost of desalinating (Calatrava and Martínez-Granados, 2012). This potential surplus may explain why 60,000 m^3 per day flow from brine, sea, brackish and wastewater sources to farmers near Almería — or it may not, as farmers cover all costs (GWI). This example will consider whether these flows represent efficiency or waste.

The local benefits of supply. According to Colino-Sueiras and Martinez-Paz (2004), Almería is one of the most important and profitable provinces for agricultural production in Spain, but don't take their word for it. The satellite image in Figure 3 illustrates the importance of using greenhouses in to grow vegetables for export.

Albiac et al. (2006) estimate water's value in production (its "shadow price") to be €3.40/m^3 in this area, which is much greater than the €0.50–1.00/m^3 cost of

FIGURE 3. Satellite photo of Campo Dalías, Almería. Source: Agujetas (2014)

desalinated water. Agujetas (2014) explains how farmers use technology to maximize their benefit from this expensive water:

> The estimated area under greenhouses in the province is currently 26,750 ha. This achievement was made possible despite the poor soil quality and high salinity that characterizes the area. Much of this success is thanks to the introduction of the *enarenado* (sand-plot) technique. This technique consists of an 8–12 cm layer of coarse sand mulch on the soil surface. The sand mulch reduces direct evaporation from the soil surface, reducing crop water use and allowing vegetables to grow with saline water. The technique was developed as an effort to overcome the extremely poor quality of indigenous soils in the region.

Figure 4 illustrates how farmers — unlike residential water users in San Diego — are willing to pay the full, marginal price of desalinated water. Their willingness to pay is useful, given the magnitude of groundwater overdrafting that threatens agricultural and urban water supplies and depletes environmental water flows. The question is whether desalination will suppress this unsustainable practice.

Who bears the costs? Overdrafting can be tackled by reducing demand or increasing surface supplies. Demand reductions are possible with a move to "efficient"

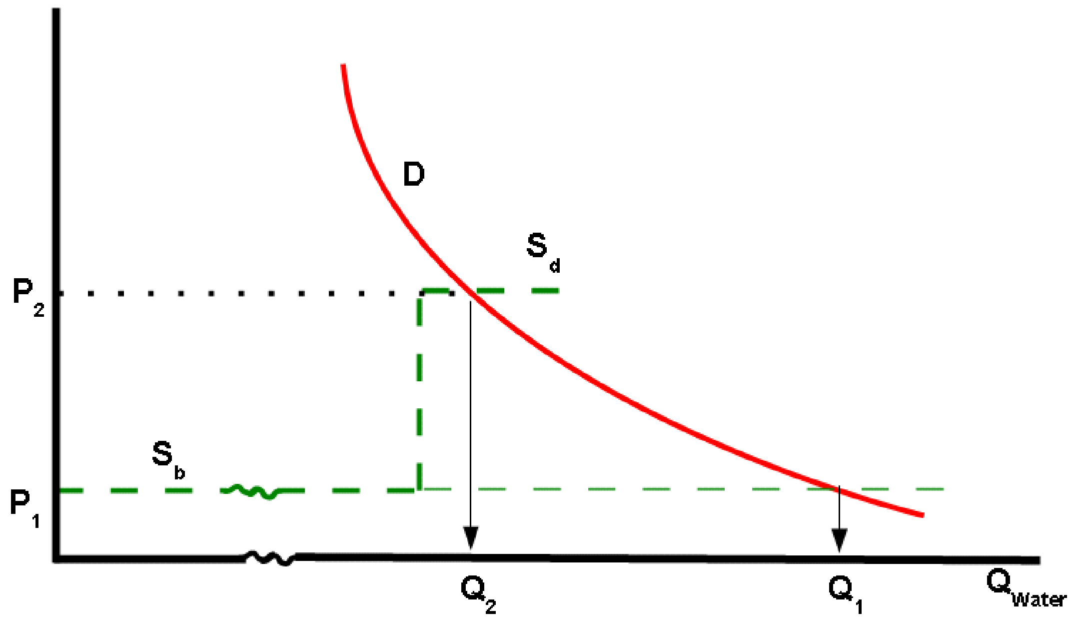

FIGURE 4. Farmers can afford to pay for desalinated water (S_d) although it costs more than groundwater (S_b), but weak regulations allow them to unsustainably overdraft groundwater for lower-valued uses such that quantity demanded is Q_1 rather than the sustainable quantity Q_2. Source: Author

irrigation; Supply substitution requires increases in surface water imports or desalination. Berbel et al. (2011) calculate the cost of reducing overdrafting to be lower than the cost of improving irrigation efficiency when it comes to protecting groundwater sources, but this action requires either a reduction in total water use (unlikely) or an increase in supply from other sources. Albiac et al. (2006) estimate that desalination is cheaper than importing water from distant exporting regions. The cost advantage grows if we include the political cost of angering opponents of exports (Gómez et al., 2013).

The Spanish government financed construction of desalination plants to help Almería's farmers use more desalted water (Albiac et al., 2006; MacMillan and Levidow, 2011), but farmers did not agree. They continued to exploit a regulatory loophole on self-supply that gave them access to cheaper, convenient groundwater. Their profit-maximizing move further depleted groundwater, but it also increased the unit cost of water from desalination plants. Those higher unit costs decreased the attraction of desalination to farmers who might have been willing to switch.

The politics of stability. After some remorse over sunk costs, the government faced a choice between selling low volumes of expensive water or subsidizing prices to increase volumes, decrease groundwater stress, and run the plants at greater efficiency. It took the latter option and reinforced the attraction of desalted water by tightening groundwater regulations (Gómez et al., 2013). This move made more sense fiscally, environmentally and socially, as higher sales would improve cost recovery, reduce groundwater overdraft, and reduce competition with small-scale and urban water users.

The government's decision may deliver net social benefits if farmers can stay in business while switching to more sustainable water supplies. The good news is that this shift is more likely to happen. Desalinated supplies allow the government to strengthen groundwater controls without facing opposition from people claiming that overdrafting "protects" jobs. This shift from jobs to profits in the discussion of "opportunity costs" makes it easier to move Spain's agriculture onto a more sustainable path.

Staying popular in Riyadh

Roman emperors spent their personal wealth on aqueducts that supplied free water to public drinking and bathing facilities. It is still possible to get free, drinkable water from free-flowing taps on Rome's streets, but household water prices are much higher. That's not the case in Riyadh in the Kingdom of Saudi Arabia (KSA), where royal subsidies lower the price of water to \$0.05/m^3 and the average household's monthly water charge is \$2. Six million Riyadhis consume an average of 280 liters each, per day.

According to GWI (2014a), most revenues for KSA's National Water Company come from industrial users, but revenues cover only 10 percent of costs that fall somewhere between \$0.80 and 2.00/m^3. Roughly half of supply comes from desalination plants located 500 km away on the Persian Gulf; the rest comes from brackish aquifers that are 400-2,400 m deep and up to 50 km away (Al-Zahrani, 2010; Ouda, 2013; Rodriguez-Vidal, 2013). Figure 5 illustrates how official prices (P_1) are far lower than the cost of service shows in S_b and S_d.

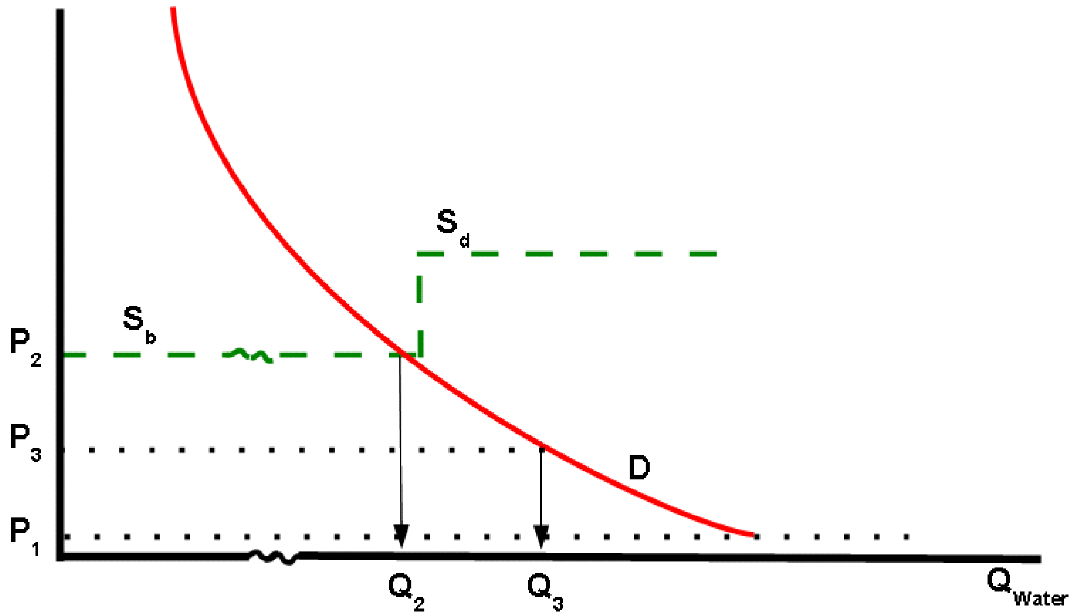

FIGURE 5. The cost of supply from groundwater (S_b) and desalination (S_d) is much higher than the price of water (P_1). Excess demand at that price is cut back by interruptions in service, such that the shadow price of water is P_3 and quantity demanded is Q_3. Source: Author

Figure 5 also shows how quantity demanded at P_1 exceeds supply, to the point where lower reliability results in a higher shadow price of water (P_2) and lower quantity demanded (Q_2). Riyadhis experience these costs through service interruptions, installing and maintaining local water storage, and spending on deliveries of tanker water. Citizens may see those costs as reasonable in a country where water is scarce and wealth divisions extreme. Indeed, it is not hard to see highly subsidized water, electricity and gasoline as quid-pro-quo offerings in exchange for political calm.

Who bears the costs? The Saudi government's current policies are relatively affordable. KSA's annual water and wastewater operating budgets are $3 billion; capital spending is double that amount (GWI, 2014a).[6] KSA earned $280 billion from exporting oil in 2013 (Mahdi, 2014).

From an environmental perspective, cheap water policies increase consumption of energy (and thus carbon emissions) and fossil groundwater. Carbon emissions

[6]The opportunity cost of current policies are considerably higher. According to USEIA (2014), KSA uses 2.9 mil bbd of oil per day for 60 percent of its energy supply (the rest comes from natural gas). Of the 2.9 mil bbd, 0.7 mil bbd goes to power. Assuming one-quarter of that quantity goes to desalination (0.175 mil bbl per day, or 3 percent of total energy use) and an oil price of $100/bbl (internal oil prices are $4-15/bbl), we can guess at an opportunity cost of $175 mil/day or $91 bil/year.

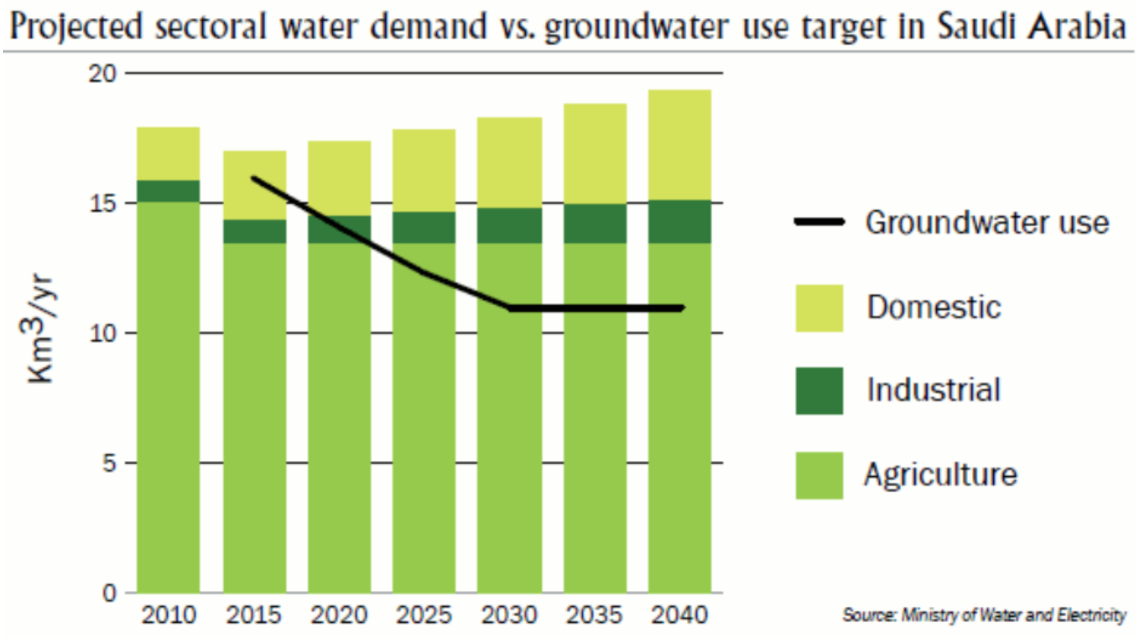

FIGURE 6. Groundwater use in Saudi Arabia. Source: GWI (2014b)

are ignored in KSA, which routinely blocks IPCC attempts to discuss energy consumption (Economist, 2014). Groundwater depletion is a larger problem, but it is driven mainly by agricultural users. Figure 6 shows that agriculture is responsible for roughly 80 percent of groundwater use. Municipal and industrial consumption, therefore, is roughly equal to aquifers' sustainable yield of 6km^3/year.

Subsidized domestic water prices increase the consumption of water, money and energy, but other policies have much larger impacts. There is no sign of reducing massive energy subsidies, but irrigation policies are evolving as fossil groundwater is depleted, the need to import food is acknowledged and cities look to groundwater as a cheaper, safer source of supply (Al-Sheikh, 1998).

The politics of stability. Riyadh's strained water system can be relieved by reducing demand or increasing supply. The government's choice appears to depend more on political calculations than economic efficiency.

Higher drinking water tariffs would reduce the demand for water — and thus pressure on aquifers, energy consumption for desalination and pumping, and the burden of subsidizing the entire system — but they would contradict the "gift-of-the-King" image of current policies. An alternative policy — paying residents to use less water — would convert "water income" into cash income. Such a policy would

probably save money, conserve resources and improve equity, but such a policy has drawbacks. First, it would turn the King's gift into a citizen's right that would impede future policy changes. Second, it would open a debate over the level of rights. A low entitlement might create a backlash from "deprived" citizens, but a high one would create an expensive obligation. These complications, combined with the current quid-pro-quo of "we give you cheap water; you respect us and don't abuse it," suggests that it may be easier to transfer agricultural water to urban uses.

Although it is possible to spend more money and energy to desalinate and transport water to Riyadh, the government appears to think it is easier to address scarcity by reducing agricultural water use. The government now requires that Saudi cows be fed with imported fodder if their milk is to be exported. Almarai (KSA's largest food company and the largest dairy company in the Middle East) has pledged to import fodder to meet domestic needs as well. Local reductions in water use will be even easier if overseas land purchases make it easier to import food (and virtual water) grown under Saudi control. These "land grabs" are controversial in some countries, but they may help both sides. Saudi farmers can grow food in a more sustainable setting while paying local labor higher wages than they received previously.[7]

Leaders in KSA want water policies that strengthen their rule. Current policies use a lot of energy for desalinating and pumping sea- and groundwater. They are expensive and environmentally harmful, but they also bring political benefits: the people enjoy practically free water as a gift from their king.

Current policies are under strain from diminishing fossil groundwater reserves and rising expectations of service. Groundwater strains are falling as the government shifts agricultural production offshore. Expectations are slowly being addressed by expanding the drinking water network and increasing hours of pressurized service. These actions are far more expensive than motivating people to use less water, but

[7]See Zetland and Moeller-Gulland (2012) for a discussion of the controversies surrounding these investments, e.g., displacing local farmers and depleting land and water resources.

TABLE 2. The cost of desalinated supplies. Energy and CO_{2e} statistics from Voutchkov (2008); GWI.

	m^3/day	CapEx (millions)	GWh/year	tons CO_{2e}/year
San Diego	190,000	$900	246	61,000
Almería	60,000	$102	55	13,570
Riyadh	420,000	$1,595	2,540	1,960,000

KSA's rulers probably prefer water populism today to conservation policies that would increase current costs for future rulers.

THE DISTANT COSTS OF LOCAL POLITICS

Our discussion so far has focussed on the direct local benefits of increasing water supplies. Politicians know that users prefer more to less water as well as cheap to dear water. Table 2 provides some back-of-envelope estimates of the direct (CapEx and energy) and indirect (carbon) costs of current, supply-side policies.[8] Figures for San Diego and Almería reflect total desalination capacity; Riyadh figures are based on 20 percent of installed capacity, i.e., the marginal capacity that allows consumption to rise from 224 LCD to 280 LCD (Doublet, 2014).

We have already discussed how local cash costs are buried in others' bills (San Diego), partially subsidized by the government (Spain), or paid almost entirely by rulers (Saudi Arabia), but desalination facilities also burden others with the indirect cost of greenhouse gas (GHG) emissions that will force climate change. San Diego plans to offset its GHG emissions (Voutchkov, 2008). Farmers in Almería pay indirectly for carbon because energy used for desalination is covered in the EU's ETS (emissions trading system), but the low cost of ETS permits (circa €5/ton CO_{2e}) means they pay almost nothing (€0.003/m^3) for GHG emissions.

Those small costs may suggest that governments can ignore the global impacts of cheap water policies, but the prominence of desalination plants suggests they play a big role in public perception and political action. The importance of perception

[8]Total operating costs include staffing, filters, and so on, but most costs — and externalities — come from energy. Saudi Arabia's energy consumption and carbon output are much higher due to differences in desalination technology. Facilities in California and Spain use reverse-osmosis (RO) technology while Saudi plants use thermal Multi-stage Flash (MSF) or Multi-effect distillation (MED). According to Anderson et al. (2008), RO produces 1.78 kg CO_2/m^3 while MSF and MED produce 23.41 and 18.05 kg CO_2/m^3, respectively.

in climate change policy means that it may be very costly to ignore these "cheap costs."

Local decisions, global impacts

This paper has explored the political benefits of increasing water supply via desalination when an economic analysis might suggest otherwise. This mismatch can be traced to the emphasis on the distribution of costs and benefits in political calculations that is often ignored in economic benefit-cost analysis. Three case studies illustrate the importance of distribution and the costs and benefits politicians experience, as those values may explain the decision to desalinate.

Leaders in San Diego, for example, preferred desalination to reducing growth or negotiating with a politically unreliable regional water supplier. Politicians in Almería preferred to subsidize desalinated irrigation water rather than restrict profitable agricultural operations. The Saudi monarchy preferred to spend vast sums to supply abundant, nearly free water to households rather than limit demand in the middle of a dry, hot desert.

Although these actions may fail a social benefit-cost test, they are not subject to that standard. Politicians who stand to gain from desalination emphasize benefits and obscure costs. In San Diego, they use average cost accounting to blend high desalination costs with lower costs from other sources rather than charging new users the marginal cost of their supply. Politicians in Spain tolerate groundwater overdrafting and subsidize desalinated water rather than openly opposing powerful agricultural interests. In Saudi Arabia, rulers deplete fossil groundwater, burn oil and ignore GHG emissions so a restless population can play with water in the desert rather than question their nation's future.

Stepping back into the world of theory, we can suppose that a policy will have the strongest political-economic foundations when users receive surplus benefits even when paying marginal costs, weaker foundations when costs fall on outsiders, and the least chance of persisting when the benefits to a local minority are subsidized by the local majority.

Turning back to the case studies, we can see how an end to desalination subsidies and groundwater overdrafting in Almería could lead to a stable equilibrium in which farmers profitably irrigate with desalted water; leaders in San Diego want to spread the high marginal costs of growth among existing customers; and Saudi rulers will continue spending heavily as they ignore GHG-emissions.

The distance between current conditions and a stable equilibrium indicate the risk of policy collapse — or the effort necessary to prevent collapse. Figures 2 and 4 illustrate the gap between current and sustainable prices and quantities (i.e., P_1, Q_1 versus P_2, Q_2) in San Diego and Almería. The gap is even larger in Riyadh (see Figure 5), where it's not even possible to meet demand at P_1 and the shadow price of unreliable services reduces demand to Q_3.

Reform may only be possible after greater changes in attitudes and relations. Greater trust between San Diego and Met would, for example, make it easier to exploit cheaper sources of supply and utilize scarcity-based price signals when meeting or regulating demand. Fair and robust groundwater management in Almería (and connected regions) would make it easier to allocate limited desalinated, ground- and surface waters among users. Reasonable charges for water services in Riyadh would reduce demand, increase system reliability, and improve long-term water security. They would also make it easier to reduce irrigation that depletes fossil groundwater that may be useful to cities worried about the security of systems stretching 500 km across the desert.

Those changes will not occur immediately, but it is useful to keep those goals and opportunities in sight while taking intermediate steps that may be facilitated by the massive size and scope of subsidies. In San Diego, it would not take too much money to restore local ecosystems that could clean and store water. In Almería, it would be fairly cheap to meter and limit groundwater pumping in stressed areas with access to desalted water. A small increase of prices in Riyadh would improve service reliability.

The pressure to reform policies is increasing as water scarcity lowers the benefits of supply-side policies relative to demand-reducing policies because the increasing risk

of shortage threatens leaders. Let us hope that they act to help their constituents and themselves.

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